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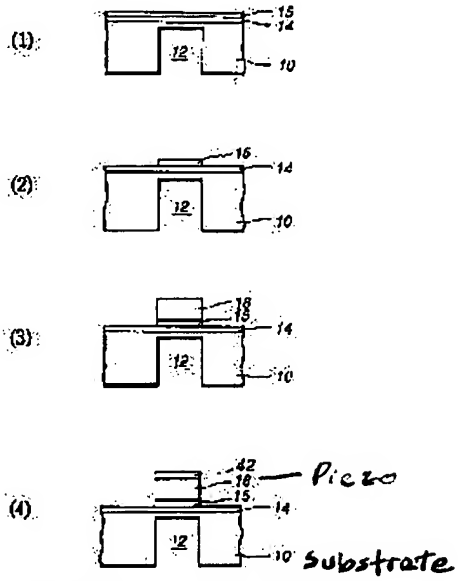
(54) PIEZOELECTRIC BODY THIN FILM ELEMENT AND ITS MANUFACTURE

(57)Abstract:
PROBLEM TO BE SOLVED: To prevent a layer of a low permittivity from being formed between a lower electrode and a PZT layer.
SOLUTION: In forming a thin film piezoelectric body 16 on a substrate 10, a PZT precursor is formed by a sol-gel method to a lower electrode 14 on the substrate 10, and crystallized in a low temperature heating process. PZT crystals are further grown by a hydrothermal synthesis method with the crystallized PZT used as a seed crystal. A temperature of the low temperature heating process is in a range of 100-300°C and the process is carried out in a hydrothermal process. According to the hydrothermal process, a solution not including PZT crystal components is heated, and the substrate is heated at the low temperature in the heated aqueous solution, thereby crystallizing the piezoelectric body precursor formed by the sol-gel method to use the precursor as the seed crystal.



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CLAIMS

[Claim(s)]
[Claim 1] The piezo electric crystal component by which said piezo electric crystal is formed on said diaphragm, without a low dielectric layer existing between the diaphragms and piezo electric crystals which were formed in said substrate in the piezo electric crystal component which comes to form a thin film piezo electric crystal in a electrocasting substrate.
[Claim 2] The piezo electric crystal component according to claim 1 to which the low dielectric layer which consists of a titanic-acid ghost does not exist between said diaphragms and piezo electric crystals.
[Claim 3] The piezo electric crystal component according to claim 1 or 2 which is that in which said diaphragm does not contain titanium mostly.
[Claim 4] The piezo electric crystal component which comes to deposit on said substrate directly in said piezo electric crystal, without being a piezo electric crystal component containing said piezo electric crystal which deposited the crystal of a piezo electric crystal, and forming a low dielectric layer between said substrates and said piezo electric crystals on a electrocasting substrate.
[Claim 5] The actuator using deformation of claim 1 thru/or said piezo electric crystal component of four given in any 1 term as a driving source.
[Claim 6] The ink jet type recording head using a piezo electric crystal component according to claim 5 as a driving source for ink regurgitation.
[Claim 7] The ink jet printer using a recording head according to claim 6.
[Claim 8] The manufacture approach of the piezo electric crystal film which forms the precursor of PZT with a sol gel process, performs low-temperature heat-treatment in the manufacture approach of a thin film piezo electric crystal, is made to crystallize this precursor, and is characterized by using a hydrothermal crystallization method based on this seed crystal, and growing up the crystal of PZT by using this crystallized PZT as seed crystal.
[Claim 9] The manufacture approach of the piezo electric crystal component which is the manufacture approach of the piezo electric crystal component using the manufacture approach according to claim 8, and is equipped with the process which forms a lower electrode on a substrate, the process which forms said seed crystal of PZT on this lower electrode, the process which carry out patterning of this seed crystal according to the pattern of an up electrode, the process which carry out crystal growth of the PZT on this seed crystal, and the process which grow up said up electrode on the crystal of PZT.
[Claim 10] The approach according to claim 8 characterized by forming on the substrate which does not contain the element used as the cause that a low dielectric layer is formed in said piezo electric crystal.
[Claim 11] Said low-temperature heat treatment is an approach according to claim 8 or 9 performed by hydrothermal processing.

[Claim 12] The approach according to claim 10 characterized by forming said piezo electric crystal on the substrate which does not contain titanium.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] Especially this invention relates to the ink jet type recording head used for an ink jet type recording apparatus etc. with respect to a thin film piezo electric crystal component. This invention relates to the manufacture approach of this piezo electric crystal component further.
[0002]
[Description of the Prior Art] Membranes are formed with spin coat methods, such as physical vapor growth (PVD), such as a spatter, chemical vapor deposition (CVD), and a sol gel process, etc., and, subsequently the piezo electric crystal thin film represented by titanic-acid lead zirconate ("PZT" is called hereafter.) is formed by receiving 700-1000-degree C elevated-temperature heat treatment.
[0003] However, the present condition was that the thickness is restricted to 1 micrometer or less. Then, in order to thicken thickness of this piezo electric crystal thin film, the assembly time for membrane formation was made to increase, and repeating membrane formation two or more times was performed.
[0004] In addition, using the hydrothermal crystallization method (it also being called a hydrothermal method.) which can consider as the approach of thickening thickness of a piezo electric crystal thin film, and can advance a reaction under a low-temperature environment 200 degrees C or less is examined.
[0005] This hydrothermal method is equipped with the seed crystal formation process of depositing PZT seed crystal on a titanium metal substrate front face, and the crystal growth process which deposits and grows up a PZT crystal further on PZT seed crystal as it is in the "creation and the electrical property of the PZT crystal film by the hydrothermal crystallization method" of for example, the collection of the 15th time electronic ingredient research debate lecture drafts of Ceramic Society of Japan which is the latest research report.
[0006] What was indicated by JP,8-118662,A exists as an approach of manufacturing an ink jet head using this hydrothermal crystallization method. The diaphragm which consists of a titanium plate is joined to a substrate, it consists of this conventional example, and the print head of a configuration of that deposited PZT in the location which counters the pressurized room of a diaphragm with the hydrothermal crystallization method, and the piezoelectric device was prepared in it is indicated.
[0007]
[Problem(s) to be Solved by the Invention] According to the place which this invention person examined wholeheartedly, there were the following problems in said conventional example. A titanic-acid ghost (TiOX) arises between the diaphragms and PZT(s) to which titanium is eluted and this changes from titanium in the process which forms PZT with a hydrothermal crystallization method. The layer which consists of this titanic-acid ghost is formed by 0.1 thru/or the thickness of 0.5 micrometers between a diaphragm and PZT. Since the above-mentioned titanic-acid ghost layer is equipped with the property of low dielectricity, it has the problem which cannot make PZT demonstrate the property as an original piezo electric crystal.
[0008] Then, this invention person proposed forming formation of the seed crystal in a hydrothermal crystallization method with a sol gel process in Japanese Patent Application No. No. 77668 [eight to]. That is, on a platinum electrode, the indication of this example of precedence uses a sol gel process, forms the seed crystal of PZT, and is related to the piezo electric crystal component into which the PZT crystal was grown up in the solution for said hydrothermal crystallization method based on this. According to this example of precedence, there is an advantage that the formation of a low dielectric layer which consists of titanic-acid-ized film on a titanium substrate unlike the conventional example into which seed crystal is grown up is barred.
[0009] However, since the process which heat-treats the precursor of PZT at an elevated temperature, and is used as seed crystal was used for this thing, it had the problem that the substrate ingredient which is equal to elevated-temperature heat treatment had to be used.
[0010] Then, this invention aims at offering the amelioration proposal of the piezo electric crystal component which formed the seed crystal of PZT by approaches other than a hydrothermal crystallization method. Namely, this invention aims at offering the piezo electric crystal component which made the process of heating for using the precursor of PZT by the sol gel process as seed crystal more possible at low temperature than before. Other purposes of this invention aim at offering the manufacture approach of the piezo electric crystal component which can use a electrocasting substrate. Other purposes of this invention aim at offering the ink jet printer equipped with an ink jet recording head and this equipped with this piezo electric crystal component.
[0011]
[Means for Solving the Problem] The outline of this invention for attaining said purpose is as follows. It faces forming a thin film

piezo electric crystal on a substrate, a PZT precursor is formed with a sol gel process on a substrate, this is crystallized by low-temperature heat-treatment, and the crystal of PZT is further grown up with a hydrothermal crystallization method by using this crystallized PZT as seed crystal.

[0012] The range of the optimum temperature of low-temperature heat-treatment is Centigrade 100 to 300 degrees, and it is suitably performed by hydrothermal processing. Hydrothermal processing here is processing which is made to crystallize the precursor of the piezo electric crystal which heated the solution which does not contain the crystal component of PZT among hydrothermal crystallization methods as stated above, carried out low-temperature heating of the substrate in this heating water solution, and was formed by said sol gel process, and is used as seed crystal. With the conventional hydrothermal crystallization method, after seed crystal formation is carried out based on seed crystal, grows up the crystal of PZT, and forms a thin film piezo electric crystal.

[0013] In this invention, in order to form seed crystal with a sol gel process, it is not necessary to use the substrate which contains titanium like the conventional hydrothermal crystallization method. Therefore, it becomes possible to avoid the problem that the titanic-acid-ized film is formed between a thin film piezo electric crystal and a substrate or between a thin film piezo electric crystal and a diaphragm (lower electrode).

[0014] In this invention, in the process which forms the seed crystal of PZT, in order to perform low-temperature heat-treatment, the electrocasting substrate which consists of nickel in which thermal resistance besides heat-resistant substrates, such as a silicon substrate, is inferior as a substrate can be used.

[0015] According to this invention, since a thin film piezo electric crystal is formed through a thing of a low dielectric like the titanium oxide film, it becomes possible to avoid the problem of the fall of the distortion property which was not avoided with a hydrothermal crystallization method. When this invention person inquires, it becomes possible to improve a distortion property 30%.

[0016] It is characterized by this invention being an ink jet type recording head which is an actuator for carrying out the regurgitation of the ink in the ink cavity by which a piezo electric crystal component is prepared in a substrate again. Furthermore, this invention is characterized by being an ink jet printer equipped with this ink jet type recording head.

[0017]

[Embodiment of the Invention] Drawing 1 shows the process of the manufacture approach of this invention. At the process of (1), the lower electrode 14 which consists of platinum is first formed by about 0.1-0.8-micrometer thickness with a spatter on the nickel electrocasting substrate 10 which was equipped with the ink cavity 12 and formed.

[0018] next, this lower electrode 14 top -- the PZT film as a piezo electric crystal thin film -- "-- the collection of the 58th Japan Society of Applied Physics academic lecture meeting lecture drafts -- it forms by referring to the approach reported by low-temperature creation" of the PZT thin film by the 512nd page, the 2 P-PA-11 sol gel process, and hydrothermal processing.

[0019] First, the precursor 15 of two component PZT shown by Pb(ZrxTi 1-x) O3+YPbO (here, it is 0.40<=X<=0.6 and 0<=Y<=0.1) is formed using the sol gel process shown below. You may be three well-known component PZT.

[0020] By this manufacture approach, dehydration processing is carried out, the hydration complex of the hydroxide of the metal component which can form the PZT film, i.e., a sol, is gelled, and the layer 15 of the precursor of the PZT film is formed.

[0021] The sol of the metal component which constitutes the PZT film can hydrolyze and adjust from an acid the metaled alkoxide or the acetate which can form the PZT film. The presentation of the PZT film mentioned above can be acquired by controlling the presentation of the metal in a sol. That is, let titanium, a zirconium, lead, each alkoxide of the metal component of further others, or acetate be a start raw material.

[0022] First, this sol constituent is applied on the lower electrode 14 with which the PZT film is formed. A lower electrode is a common electrode and functions as a diaphragm. Especially the method of application at this time is not limited, but the approach usually performed, for example, a spin coat, a DIP coat, a roll coat, a bar coat, etc. can perform it. Moreover, it can also apply by flexographic printing, screen-stencil, offset printing, etc.

[0023] Hydrothermal processing is performed to the precursor of PZT which consists of this sol constituent, and this precursor is crystallized. This PZT functions as seed crystal for growing up the crystal of PZT like the after-mentioned.

[0024] First, the thickness of the film of the PZT precursor formed of spreading is a complement in order to form the thickness of PZT which demonstrates the piezo-electric distortion property demanded. For example, when manufacturing an ink jet type recording head, it is the range of 0.1-1 micrometer, and 0.2-0.6 micrometers is desirable especially. the process of spreading of a sol constituent -- one by one -- multiple times -- it is carried out about 2 to 6 times suitably.

[0025] Next, hydrothermal processing is performed to the electrocasting substrate with which the applied sol constituent was formed. The substrate containing a PZT precursor is dipped in the alkali water solution (the raw material component for forming PZT is not included mostly) (OH) 2, for example, 0.5MBa, and it heats on 0.8MPa(s) and 160-degree C conditions in an autoclave. The precursor of PZT is heated by this, it crystalizes and the PZT seed crystal of a perovskite mold is formed.

[0026] Subsequently, as shown in drawing 1 (2), patterning of the PZT of a garbage is removed and carried out by ion milling. Especially the approach of patterning is not limited. Furthermore, as shown in (3), the crystal of PZT is grown up on the seed crystal of PZT which applied the hydrothermal crystallization method to this substrate, and remained, without being removed. That is, the film (layer) 16 of PZT is grown up according to hydrothermal reaction on the PZT seed crystal 15 by the sol gel process acquired by doing in this way. The reaction solution used by this hydrothermal reaction is adjusted by mixing lead acetate Pb(NO3)2 water solution, zirconium oxychloride ZrOCl2 water solution, titanium chloride TiCl4 water solution, and a potassium-hydroxide KOH water solution. Thereby, PZT16 grew to 3 micrometers. Subsequently, as alternatively shown further at drawing 1 (4) using techniques, such as electron beam vacuum deposition and a spatter, on PZT16, the up electrode 42 is

formed. Platinum (Pt) / gold (Au) is used for the ingredient of an up electrode. Thickness is set to about 100nm.
[0027] In addition, without carrying out patterning of the seed crystal of PZT, the crystal of PZT may be grown up and an upper electrode may be formed, and you may constitute so that etching may remove the piezo electric crystal and upper electrode of a garbage.
[0028] Then, a desired process is performed and an ink jet type recording head is completed, such as joining the nozzle plate which has a nozzle for ink regurgitation to the open field side of the ink room obtained by doing in this way.
[0029] According to this manufacture approach, in process of hydrothermal reaction, the PZT film can attain the effectiveness that the rate of crystallization improves, in order to crystallize based on seed crystal. Therefore, since time amount which hydrothermal reaction takes can be shortened, it is prevented that a substrate receives damage with an alkali water solution. Furthermore, orientation of the crystal of the PZT film is carried out to a field (100) or (111) a field by controlling membrane formation conditions in the orientation of seed crystal at this time. If cleaning temperature is 350 degrees C or less (111), orientation will be obtained, and orientation will be obtained if cleaning temperature is 400 degrees C or more (100).
[0030] The diameter of crystal grain of a piezo electric crystal thin film is 0.05 micrometers or more 0.5 micrometers or less. If it is 10 micrometers or less while a required piezo-electric property will be acquired in an ink jet type recording head, for example, if the thickness of a piezo electric crystal thin film is 1 micrometers or more, a piezo electric crystal component can be formed in high density. It is 1 thru/or 5 micrometers suitably, and is 2 micrometers still more suitably.
[0031] If the diameter of crystal grain is 0.05 micrometers or more, a required piezo-electric property can be demonstrated. If the diameter of crystal grain is 1 micrometer or less, patterning with a detailed piezo electric crystal thin film will become possible. This numeric value is realized by the structure of crystallizing a piezo electric crystal thin film further, by using seed crystal with a detailed piezo electric crystal thin film as a nucleus. Furthermore, when surface roughness makes it 1 micrometer or less by Rmax, an up electrode can cover a piezo electric crystal thin film enough.
[0032] The ink jet type recording head 1 shown in drawing 2 is a type with which the feeder current way of ink is formed in a pressurized-room substrate. As shown in this drawing, an ink jet type recording head mainly consists of pressurized-room substrate 20A, a nozzle unit 2, and a base 25.
[0033] After pressurized-room substrate 20A is formed on a silicon single crystal substrate, it is divided into each. The pressurized room 21 of the shape of two or more strip of paper is formed, and pressurized-room substrate 20A is equipped with the common passage 23 for supplying ink to all the pressurized rooms 21. 24 is a feed hopper for supplying ink to each ink room. It is separated by the side attachment wall 22 between pressurized rooms 21. Diaphragm 30A is prepared in the base 25 side of the pressurized-room substrate 21. Moreover, it converges on the wiring substrate which is a flexible cable, and wiring from each piezo electric crystal thin film is connected with the external circuit of a base.
[0034] Nozzle plate 10A is joined to pressurized-room substrate 20A. The nozzle 11 for extracting an ink droplet is formed in the location corresponding to the pressurized room 21 in a nozzle plate. Bases 25 are ****, such as a metal, and serve as a mount of pressurized-room substrate 20A.
[0035] Next, the structure of a printer where the ink jet type recording head which has the piezo electric crystal component shown in drawing 2 is used is explained to drawing 3 . A tray 3, an exhaust port 4, and the various manual operation buttons 9 are formed in the body 2 by the printer so that a function may be possible as a line printer. Furthermore, the interior of a body is equipped with the ink jet type recording head, the feeder style 6, and the control circuit 8.
[0036] An ink jet type recording head is equipped with a piezo electric crystal component as stated above. Especially, this head is a head for line printers, and the width of face of the form which can be supplied is formed in wrap die length. The ink jet type recording head consists of nozzles prepared to the limit of the width of face of a form possible [the regurgitation / ink] corresponding to the regurgitation signal supplied from a control circuit.
[0037] The feeder style is equipped with the machine structure of a motor 600 and roller 601,602 grade. The motor is pivotable corresponding to the driving signal Sd supplied from a control circuit. Machine structure is constituted possible [transfer on a roller] in the turning effort of a motor. A roller draws the form which rotated when the turning effort of a motor was transmitted, and was laid in the tray by rotation, and supplies it possible [printing] by the head.
[0038] A control circuit is equipped with CPU, ROM, RAM, an interface circuitry, etc., is made to correspond to the printing information supplied from a computer through a connector, and a driving signal can be supplied to a feeder style, or it can supply a regurgitation signal now to an ink jet type recording head. Moreover, a control circuit makes the actuation signal from a control panel correspond, and can perform now setup of a mode of operation, reset processing, etc.
[0039]
[Effect of the Invention] Since the layer which becomes the substrate with which PZT is formed, and a lower electrode from a low dielectric constant is not formed according to this invention as explained above, the piezo electric crystal component excellent in the piezo-electric property can be offered. Moreover, since the precursor of PZT formed by the sol gel process is crystallized by low-temperature heat-treatment and it was made to grow up the crystal of PZT by making this into seed crystal according to this invention, it becomes possible to use the substrate which does not fit high temperature processing like a electrocasting substrate.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the sectional view showing the production process of the ink jet record type head concerning this invention.
[Drawing 2] It is the block diagram of an ink jet recording head.
[Drawing 3] It is the perspective view of the ink jet printer using this ink jet recording head.
[Description of Notations]
10: A nickel electrocasting substrate, 12:ink room, 14 : a lower electrode, 15 :P ZT precursor, 16 :P ZT crystal growth layer

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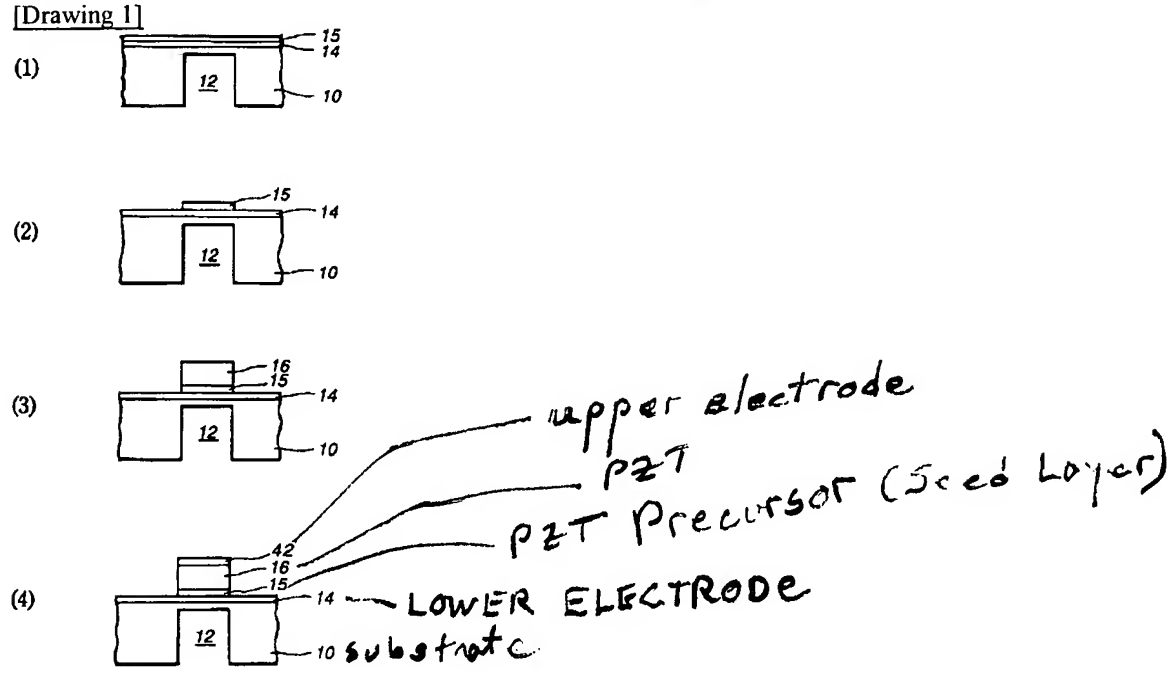
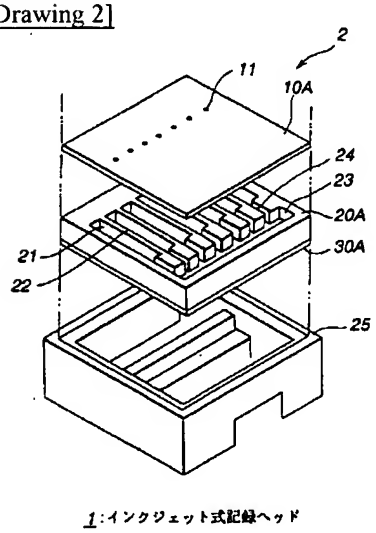
[Translation done.]

DRAWINGS

[Drawing 1]

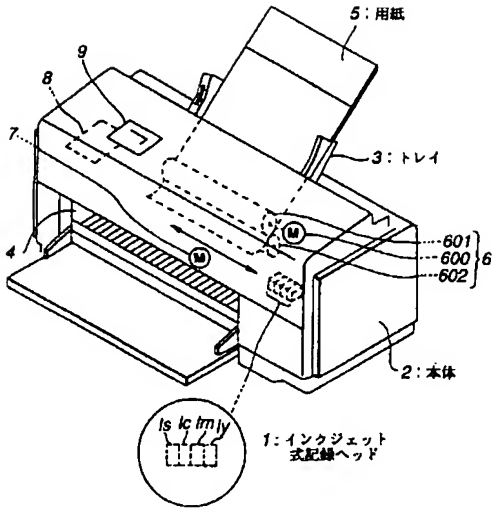


[Drawing 2]



1:インクジェット式記録ヘッド

[Drawing 3]



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